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Marketta Tehikoski

Marketta Tehikoski
Apulaistarkastaja

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Maksu 300,- mk
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Osoite: Arkadiankatu 6 A
P.O.Box 1160
FIN-00101 Helsinki, FINLAND
Puhelin: 09 6939 500
Telephone: + 358 9 6939 500
Telefax: 09 6939 5328
Telefax: + 358 9 6939 5328

A radio link system
Radiolinkkijärjestelmä
Radiolänksystem

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is directed to microwave radio link systems, especially to such systems as described in the preamble of claim 1.

2. Description of Related Art

The invention concerns point-to-multipoint (PMP) radio systems, in which the access points (AP) operate in full-duplex mode and terminals (Access Terminal, AT) operate in half-duplex mode. Figure 1 illustrates the structure of such a system. Figure 1 shows terminals 10, an access point 20, and a telecommunications network 30. Typically such systems are used to provide fixed wireless connections between a central station i.e. an access point 20 (AP) and several fixed substations i.e. access terminals 10 (AT). Such systems are very advantageous in environments, where provision of fixed lines would cause prohibitive costs, such as in cities. Typically such systems are used to link base stations of a cellular telecommunications network to a central station 20, which is connected to rest of the telecommunications network 30. Such systems are also often used for providing wireless local area networks (WLAN). Such systems are also often used to provide connections between public networks and private business and residential customers.

In many cases such systems use time division to separate signals of the terminals from each other, i.e. they are arranged to transmit at different times. For simplicity and reasons of cost, terminals typically operate in half-duplex mode, i.e. the terminals cannot transmit and receive at the same time. The access points are typically capable of full-duplex operation. The number of access points in a network is considerably lower than the number of terminals, whereby the requirements for low cost are not as stringent as in the case of terminals and the structure of access points can be more complicated.

One example of such a system is the HIPERACCESS and HIPERLAN systems specified by the European Telecommunications Standards Institute. The HIPERACCESS system is described in detail in the ETSI specification DTR/BRAN-010001 "Broadband Radio Access Networks (BRAN): Requirements and architectures for HIPERACCESS fixed networks".

According to current ETSI Bran Hiperlan/2 (HL2) draft specifications each terminal has to listen to a broadcast message (BM) at regular intervals, once in a constant length frame. Half-duplex terminals cannot send during that time even though the AP is always able to receive, since the AP operates in full duplex mode. Thus the uplink channel is idle during that time and radio interface capacity is wasted.

SUMMARY OF THE INVENTION

An object of the invention is to realize a PMP radio link system, which avoids the problems of prior art. A further object of the invention is to realize a PMP radio link system, which is able to use the capacity of the radio interface better than systems according to prior art.

The objects are reached by arranging the terminals into two groups, arranging a first group of the two groups to listen during a first half of a time period, arranging the second group of the two groups to listen during the second half of the time period, and sending broadcast messages twice i.e. once during said first half of the time period and once during said second half of the time period.

The system according to the invention is characterized by that, which is specified in the characterizing part of the independent claim directed to a system. The access point according to the invention is characterized by that, which is specified in the characterizing part of the independent claim directed to a access point. The terminal according to the invention is characterized by that, which is specified in the characterizing part of the independent claim directed to a terminal. The method according to the invention is characterized by that, which is specified in the characterizing part of the independent method claim. The dependent claims describe further advantageous embodiments of the invention.

According to the invention, the terminals are grouped into two groups. A first group of the two groups is arranged to listen during a first half of a time period and a second group of the two groups is arranged to listen during the second half of the

time period. The broadcast messages are sent twice i.e. once during said first half of the time period and once during said second half of the time period, whereby all terminals are able to receive the broadcast messages, and half of the terminals are able to transmit at the time when the other half is receiving a broadcast message.

The broadcast messages transmitted by the access point comprise various control information, such as for example the identifier of the access point, identifier of the network operator, and identifier of the transmission sector. The broadcast messages may also comprise other types of information such as information about an access time slot, during which new terminals may initiate communication with the access point. The broadcast messages also indicate the reception periods of individual terminals. Consequently, the two broadcast messages have some parts in common, while terminal-specific parts are naturally different in the two broadcast messages of a frame.

Typically, the access point specifies the transmission periods allocated for a terminal in an individual transmission to the terminal, along with other terminal specific control information and possibly payload data. A terminal does not need to receive during other times as the broadcast message times and reception times indicated by the AP. During the other times, a terminal may transmit if transmission is allowed by the AP, or the terminal may be in idle mode in order to save power.

Each terminal advances the granted time values by the double propagation delay given by AP, so that the transmission of the terminal arrives at the access point at the indicated time, and conversely for reception.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in more detail in the following with reference to the accompanying drawings, of which

Figure 1 illustrates a PMP system according to prior art, and

Figure 2 illustrates timing according to an advantageous embodiment of the invention.

Figure 3 illustrates timing according to a further advantageous embodiment of the invention,

Same reference numerals are used for similar entities in the figures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A. A FIRST GROUP OF ADVANTAGEOUS EMBODIMENTS

In the following, an advantageous embodiment of the invention is described with reference to figure 2. Figure 2 illustrates the timing of listening and transmission times of various parties of a PMP system, i.e. the timing of a first group GROUP A, a second group GROUP B and an access point AP. White rectangles denote listening times, hatched rectangles denote time when a party may transmit and dotted rectangles denote actual transmission. Time T_0 denotes the beginning of a frame and time T_1 denotes the end of that frame and the beginning of the second frame. Time T_2 denotes the middle of the frame. According to the present advantageous embodiment of the invention, terminals in the first group GROUP A listen during the time period T_0 to T_2, and may transmit in the time period T_2 to T_1. Terminals in the second group GROUP B may transmit during the time period T_0 to T_2, and they listen in the time period T_2 to T_1. The access point transmits a broadcast message during the interval between times T_3 and T_4, which are both between times T_0 and T_2. The terminals in the first group GROUP A receive the message during that time, while terminals in the second group GROUP B may transmit during that time. At time T_2, terminals in the second group GROUP B begin to listen, and the access point transmits the second broadcast message during the interval between times T_5 and T_6, which are both between times T_2 and T_1. The terminals in the second group GROUP B receive the message during that time, while terminals in the first group GROUP A may transmit during that time.

In one advantageous embodiment of the invention, the broadcast messages are sent in the beginning of the frame and in the middle of the frame, i.e. times T_0 and T_3 are the same and T_2 and T_5 are the same.

B. A SECOND GROUP OF ADVANTAGEOUS EMBODIMENTS

In the following, a further advantageous embodiment of the invention is described with reference to figure 3. Figure 3 illustrates the timing of listening and transmission times of various parties of a PMP system, i.e. the timing of a first group GROUP A, a second group GROUP B and an access point AP. White

rectangles denote listening times, hatched rectangles denote time when a party may transmit and dotted rectangles denote actual transmission. Time T_0 denotes the beginning of a frame and time T_1 denotes the end of that frame and the beginning of the second frame. The first broadcast message is transmitted during the interval between times T_3 and T_4, and the second broadcast message during the interval between times T_5 and T_6. According to the present advantageous embodiment of the invention, terminals in the first group GROUP A listen during the time period T_3 to T_4, and may transmit during other times. Terminals in the second group GROUP B listen during the time period T_5 and T_6, and may transmit during other times.

In a further advantageous embodiment of the invention, the broadcast messages are sent in the beginning of the frame and in the middle of the frame, i.e. times T_0 and T_3 are the same and T_2 and T_5 are the same.

The two broadcast messages preferably comprise an identifier indicating which of the two broadcast messages a particular broadcast message is. Such an identifier allows terminals to recognize if a particular broadcast message is directed to the group it belongs to or to the other group. The identifier can be for example in the form of a bit pattern in the beginning of the broadcast message.

The allocation of actual transmission turns for the terminals for the time periods when the terminals may transmit can be performed in many ways. One advantageous method for allocating the transmission turns is described later in this specification.

According to an advantageous embodiment of the invention, the grouping of terminals to two groups is performed without any signalling from the access point. The grouping can advantageously be based on a device dependent parameter such as a device serial number or some other equipment identifier, more specifically on the value of the least significant bit of such an identifier. The terminal therefore knows which group it belongs to without any explicit signalling from the access point. This arrangement ensures, that almost any set of terminals can be grouped into two groups of roughly equal size.

According to a further advantageous embodiment of the invention, the access point can instruct one or more terminals to switch groups, if the sizes of the groups are too unequal.

C. A THIRD GROUP OF ADVANTAGEOUS EMBODIMENTS

Access point manages transmission timing of the terminals according to certain rules such that uplink capacity can be in full use. In the following, one example of such rules according to an advantageous embodiment is described.

The access point grants permissions to terminals to send uplink data based on transmission requests it has received from the terminals. The AP calculates and organizes the time slots so that each terminal does not need to receive downlink data and send uplink data simultaneously, thus allowing half-duplex operation for the terminals. When performing uplink time slot calculation, the AP preferably takes into account the downlink propagation times from AP to each AT and uplink propagation times from each AT to the AP.

At first the access point (AP) allocates the total available frame periods in near future to terminals (AT) by calculating the amounts of time each terminal will be granted in downlink and uplink. The access point (AP) knows how much transmission capacity each terminal needs, since the access point knows the connection types of the terminals. For obtaining this information for packet connections, the access point can periodically poll the terminals. Also, the terminals can indicate to the access point that they have data waiting to be transmitted. For example, the access point can periodically arrange a time slot for that purpose, during which any terminal having data waiting to be transmitted can send such an indication. After calculating the amounts of time needed by the terminals, the scheduler allocates exact time slots for the reception and transmission times of the terminals using a certain set of rules and trying to fulfill the amounts of time needed by the terminals and the requirements of the rules in an as optimal way as possible. One set of such rules according to an advantageous embodiment of the invention is described in the following. It is specifically noted here that the following is an example only, and other sets of rules for determining the transmission and reception times for the terminals could be used.

Only those terminals who need transmission or reception capacity are considered. Terminals are ordered according to the distance i.e. the time delay of the terminal from the access point. The transmission/reception time slot of the terminal of the first group (group A) which is closest to the access point is here denoted A_1, and that of the one furthest from the access point A_n. Similarly, the transmission/reception time slots of terminals of the second group (group B) are denoted from B_1 to B_n according to the distance of the terminal from the access

point. The distance i.e. the time delay of the terminals from the access point is known by the access point, since during the phase when a new terminal initiates communications with the access point, the access point adjusts the timing of the terminals so that the transmissions of the terminal arrive at the access point at the desired times. Therefore, both the access point and the terminal know the time delay caused by the propagation of the radio signal from the terminal to the access point or vice versa.

The broadcast message directed to terminals of the first group is denoted BM_A in the following, and the broadcast message to terminals of the second group is denoted BM_B.

In the downlink transmission, the access point aims to transmit BM_A in the beginning of the frame and BM_B in the middle of the frame. The position of BM_B within a frame is not very critical. However, it is very advantageous if successive first broadcast messages BM_A are repeated with a period of one frame period, and the second broadcast messages BM_B as well with a period of one frame period, which allows the terminals to adjust exactly to their respective broadcast message timing without having to listen and wait for a broadcast message to occur.

If the same capacity is needed for group A terminals as for group B terminals, the transmissions of the AP are organized as follows:

$$BM_A, B_1, \ldots, B_n, BM_B, A_1, \ldots, A_n \qquad (1)$$

That is, the first broadcast message BM_A is transmitted first, followed by transmissions directed to individual terminals in group B, whereafter the second broadcast message BM_B is transmitted, followed by transmissions directed to individual terminals in group A.

In the case that the terminals in group B need to receive longer than terminals in group A, the transmissions of the AP are organized as follows:

$$BM_A, B_1, \ldots, B_k, BM_B, B_{k+1}, \ldots, B_n, A_1, \ldots, A_n \qquad (2)$$

That is, the first broadcast message BM_A is transmitted first, followed by transmissions directed to individual terminals in group B. The second broadcast message BM_B is transmitted in or as closely after the middle of the frame as

possible, followed first by those transmissions to terminals in group B which did not fit in the frame between the two broadcast messages. The frame is finished by transmissions directed to individual terminals in group A.

In the case that the terminals in group B need to receive for a shorter time than terminals in group A, the transmissions of the AP are organized as follows:

$$BM_A, B_1, \ldots, B_n, A_1, \ldots, A_k, BM_B, A_{k+1}, \ldots, A_n \qquad (3)$$

That is, the first broadcast message BM_A is transmitted first, followed by transmissions directed to individual terminals in group B. After these, transmissions to terminals in group A are started, and the second broadcast message BM_B is transmitted in or as closely after the middle of the frame as possible. The frame is finished by transmissions to those terminals in group A, whose transmissions did not fit in the first half of the frame.

Since the terminals need to be instructed when to receive data, a terminal cannot receive data before it has been instructed about the correct time. Consequently, in the previous schemes, the reception times for at least those terminals of the B group whose reception times are before the BM_B of the current frame, have been specified in the BM_B of the previous frame, and preferably the reception times of the rest (if any) of B terminals as well. The broadcast messages may specify reception and transmission times for a longer time span than one frame.

The previous schemes (1), (2) and (3) have the advantage, that a terminal does not need to receive directly after reception of a broadcast message informing the terminal about its reception time. Without such an arrangement, an idle period may need to be used after a broadcast message, since the interpretation of the contents of a broadcast frame does not happen instantaneously due to the processing time needed to decode a broadcast message, which are typically encoded in various ways in order to enable error correction. However, in the previous schemes (1), (2) and (3) the terminal to which the transmission after a broadcast message is directed is able to receive the transmission, since the broadcast message is directed to terminals of the other group. For example, after BM_A, terminal B_1 is able to receive data at once, since that terminal is not busy decoding BM_A.

For the transmissions, the access point takes into account a guard period, which is required between the reception and transmission periods of a terminal in order to

allow the terminal to change between transmission and reception operating modes. When performing the allocation, the access point adjusts the transmission and reception times so that none of the terminals is required to send within the guard period after or before a reception period of the particular terminal.

In the uplink direction, the closest terminal of group A is allowed to send after the guard period after the end BM_A, whereafter transmission periods are granted to other terminals in group A in order of distance, i.e. the second closest terminal next and so on. After the A terminals, transmission periods are granted to terminals in group B similarly in order of distance.

D. FURTHER ADVANTAGEOUS EMBODIMENTS OF THE INVENTION

According to an advantageous embodiment of the invention, a system for providing wireless point-to-multipoint connections is provided. Said system comprises an access point using full-duplex mode and terminals using half-duplex mode. In said system,

- each of a plurality of the terminals has an equipment identifier,
- each of said plurality of the terminals is arranged to classify itself as belonging to a first group of terminals or a second group of terminals based on said equipment identifier according to a predefined rule; and
- the access point is arranged to send a first broadcast message to said first group of terminals and a second broadcast message to said second group of terminals, and
- the access point is arranged to schedule the transmission period of at least one terminal of said second group to overlap at least partly with the transmission period of said first broadcast message.

In order to realize said functionality of classifying, sending and scheduling, said system preferably comprises means for classifying said terminals in said terminals, means in the access point for sending a first broadcast message and a second broadcast message to a first group of terminals and to a second group of terminals respectively, and means in the access point for scheduling transmission periods of terminals. Said means for classifying, sending and scheduling can advantageously be implemented using processors executing software program elements stored in a memory means in the particular system element.

According to a further advantageous embodiment, in said system the access point is arranged to schedule the transmission period of at least one terminal of said first

group to overlap at least partly with the transmission period of said second broadcast message.

According to a still further advantageous embodiment of the invention, an access point of a point-to-multipoint wireless link system is provided. According to the embodiment, the access point is arranged to send a first broadcast message in a frame to a first group of terminals and a second broadcast message in said frame to a second group of terminals, and the access point is arranged to schedule the transmission period of at least one terminal of said second group to overlap at least partly with the transmission period of said first broadcast message.

In order to realize said functionality of sending and scheduling, the access point preferably comprises means for sending a first broadcast message and a second broadcast message to a first group of terminals and to a second group of terminals respectively; and means for scheduling transmission periods of terminals. Said means for sending and scheduling can advantageously be implemented using a processor of the access point executing software program elements stored in a memory means in the access point.

According to another advantageous embodiment of the invention, a terminal of a point-to-multipoint wireless link system is provided, which terminal has an equipment identifier. According to the embodiment, the terminal is arranged to classify itself as belonging to a first group of terminals or a second group of terminals based on the equipment identifier according to a predefined rule. In order to realize said functionality of classifying the terminal preferably comprises means for classifying the terminal. Said means for classifying can advantageously be implemented using a processor of the terminal executing software program elements stored in a memory means in the terminal. According to a further advantageous embodiment, the terminal is arranged to perform the classification based on the value of the least significant bit of the identifier.

According to a yet further advantageous embodiment of the invention, a method for providing wireless point-to-multipoint connections between an access point and a plurality of terminals is provided. In the method, the terminals are grouped into a first group and a second group, during a transmission frame, the access point sends a first broadcast message to terminals in the first group and a second broadcast message to terminals in the second group, and at least one of the terminals of the second group is scheduled to transmit during at least a part of the transmission

period of said first broadcast message. In a further advantageous embodiment, in said method at least one of the terminals of the first group is scheduled to transmit during at least a part of the transmission period of said second broadcast message.

E. FURTHER CONSIDERATIONS

The invention has several advantages. For example, the invention allows the elimination of idle time in the uplink direction during broadcast message transmissions in the downlink direction.

The invention has been described in the following as applied in the HIPERACCESS and HIPERLAN systems, but the invention is not limited to application in those systems. The invention can be used in any other PMP radio link systems, where a central station using full-duplex mode communicates with slave stations using half-duplex mode.

In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention. While a preferred embodiment of the invention has been described in detail, it should be apparent that many modifications and variations thereto are possible, all of which fall within the true spirit and scope of the invention.

Claims

1. System for providing wireless point-to-multipoint connections having an access point using full-duplex mode and terminals using half-duplex mode, **characterized** in that
- each of a plurality of the terminals has an equipment identifier,
- each of said plurality of the terminals is arranged to classify itself as belonging to a first group of terminals or a second group of terminals based on said equipment identifier according to a predefined rule; and
- the access point is arranged to send a first broadcast message to said first group of terminals and a second broadcast message to said second group of terminals, and
- the access point is arranged to schedule the transmission period of at least one terminal of said second group to overlap at least partly with the transmission period of said first broadcast message.

2. A system according to claim 1, **characterized** in that
- the access point is arranged to schedule the transmission period of at least one terminal of said first group to overlap at least partly with the transmission period of said second broadcast message.

3. Access point of a point-to-multipoint wireless link system, **characterized** in that
- the access point is arranged to send a first broadcast message in a frame to a first group of terminals and a second broadcast message in said frame to a second group of terminals, and
- the access point is arranged to schedule the transmission period of at least one terminal of said second group to overlap at least partly with the transmission period of said first broadcast message.

4. Terminal of a point-to-multipoint wireless link system, which terminal has an equipment identifier, **characterized** in that
the terminal is arranged to classify itself as belonging to a first group of terminals or a second group of terminals based on the equipment identifier according to a predefined rule.

5. The terminal according to claim 4, **characterized** in that
the terminal is arranged to perform the classification based on the value of the least significant bit of the identifier.

6. Method for providing wireless point-to-multipoint connections between an access point and a plurality of terminals, **characterized** in that
- the terminals are grouped into a first group and a second group,
- during a transmission frame, the access point sends a first broadcast message to terminals in the first group and a second broadcast message to terminals in the second group, and
- at least one of the terminals of the second group is scheduled to transmit during at least a part of the transmission period of said first broadcast message.

7. The method of claim 6, **characterized** in that
at least one of the terminals of the first group is scheduled to transmit during at least a part of the transmission period of said second broadcast message.

ABSTRACT

The invention is directed to microwave radio link systems. The invention concerns point-to-multipoint (PMP) radio systems, in which the access points (AP) operate in full-duplex mode and terminals (Access Terminal, AT) operate in half-duplex mode. According to the invention, the terminals are grouped into two groups. A first group of the two groups is arranged to listen during a first half of a time period and a second group of the two groups is arranged to listen during the second half of the time period. The broadcast messages are sent twice i.e. once during said first half of the time period and once during said second half of the time period, whereby all terminals are able to receive the broadcast messages, and half of the terminals are able to transmit at the time when the other half is receiving a broadcast message.

Figure 2

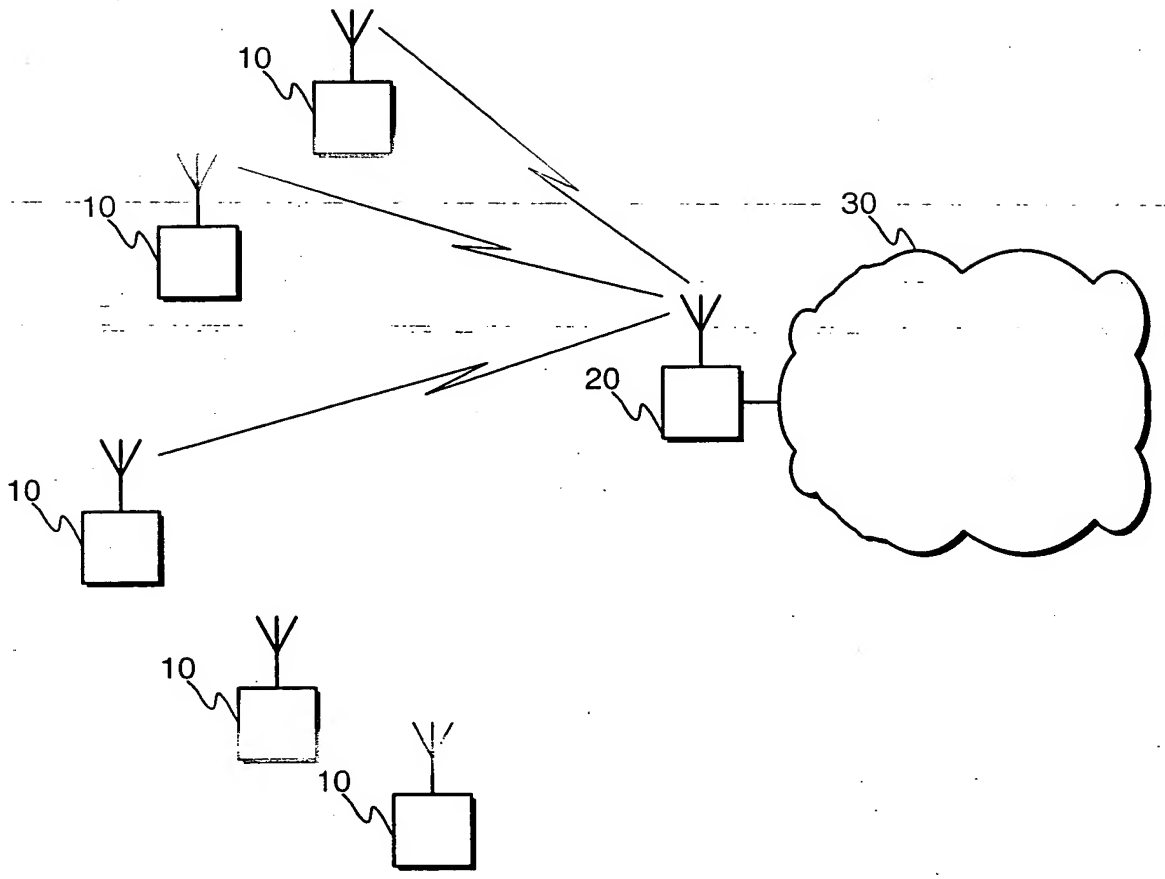

Fig. 1

PRIOR ART

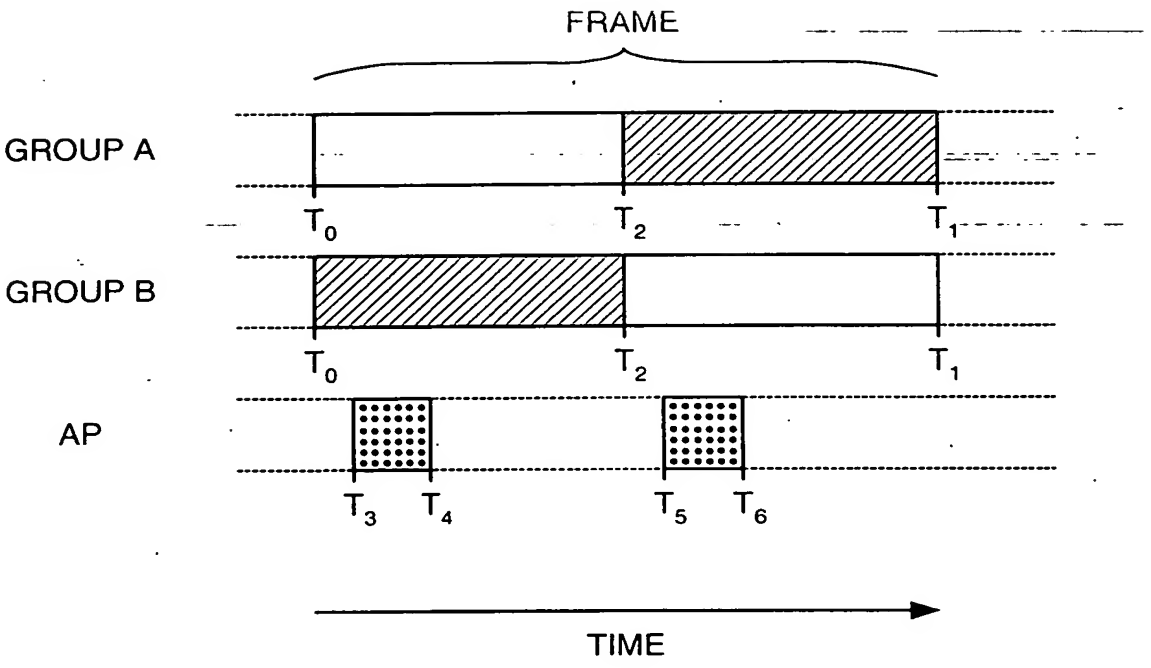

Fig. 2

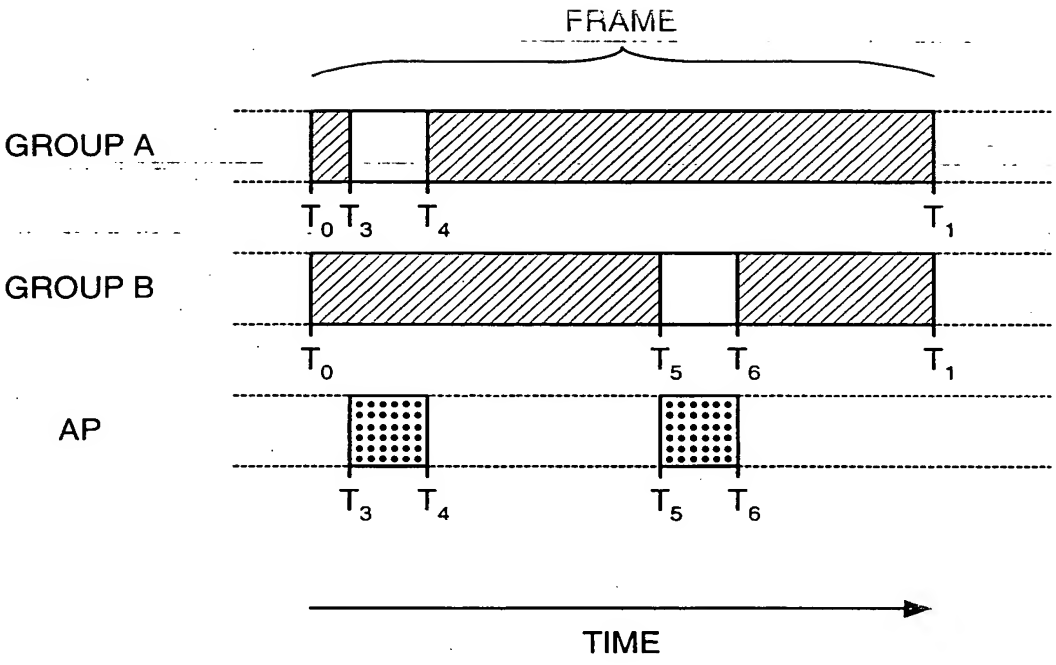

Fig. 3